UM0787
User manual

STM32W108 ZigBee® starter kit (beta version)

1 Introduction

This document describes the STM32W108 ZigBee® starter kit (beta version) (order code: STM32W-SK), an RF tool you can use to evaluate the capabilities of the STM32W108 device for RF communication based on the IEEE 802.15.4-2006 standard for the ZigBee communication protocol.

The STM32W108 ZigBee starter kit (beta version) provides all the capabilities for developing:

- RF evaluation applications that target basic RF tests, communication and light ZigBee software development.
- RF networking applications that target more complex ZigBee applications.

The STM32W108 ZigBee starter kit (beta version) reference platform is based on the STM32W108 application board (MB851). This platform enables running specific ZigBee applications supporting the EmberZNet™ PRO stack using the STM32W108 microcontroller. Further, it enables user interaction through the use of buttons, LEDs and serial communication protocols.

The STM32W108 ZigBee starter kit (beta version) software includes the EmberZNet™ stack for the STM32W108 RF microcontroller which consists of:

- ZigBee PRO stack libraries
- HAL (hardware abstraction layer) APIs (application programming interfaces) for driving the STM32W108 microcontroller and hardware resources for related boards (button, LEDs, USB)
- Application utility APIs for addressing specific ZigBee PRO features (form/join, ZDO, message fragmentation and Network Manager)
- Application utility APIs for serial communication management
- ZigBee PRO application demos that address a wide range of ZigBee PRO features (including the ZDO and the HA, SE profiles).
- Fully documentation about the STM32W108 microcontroller, STM32W108 boards, Doxygen documentation for EmberZNet ZigBee PRO stack APIs, HAL APIs and application utility APIs.

More details on the STM32W108 ZigBee starter kit (beta version), including hardware and software resources are provided in the following sections.

Contents

2 Description of the delivered packages

Each STM32W108 ZigBee starter kit (beta version) package contains the following items:

- Three STM32W108 application boards (MB851)
- One JTAG adaptation board (MB885)
- One IAR J-Link (USB-JTAG/SWD) debug probe
- One CD-ROM including the Daintree SNA evaluation version
- One CD-ROM including the IAR Limited Compiler 5.30 (a patch is needed to support STM32W108 microcontrollers)

Note: 1 The starter kit (beta version) boards are pre-programmed as follows:

- *One ZigBee sink firmware (board labeled as "Sink")*
- *One ZigBee sensor firmware (board labeled as "Sensor")*
- *One Daintree capture firmware (board labeled as "Analyzer")*

2 The EmberZNet stack and the related documents can be downloaded from the www.st.com/mcu STM32W section.

2.1 Hardware overview

2.1.1 STM32W108 microcontroller

The STM32W108 is a fully integrated System-on-Chip that integrates a 2.4 GHz, IEEE802.15.4-compliant transceiver, 32-bit ARM® Cortex™-M3 microprocessor, Flash and RAM memory, and peripherals of use to designers of ZigBee-based systems. For detailed information about the STM32W108 microcontroller, please refer to the related technical documentation.

2.1.2 STM32W108 application board

The STM32W108 application board (MB851) is equipped with:

- A STM32W108 system-on-chip that integrates a 2.4 GHz, IEEE 802.15.4-compliant transceiver, 32-bit ARM® Cortex M3 microprocessor
- A set of sensors to detect temperature and acceleration
- A button and 2 LEDs for user interaction
- An infrared LED
- A mini-USB connector for serial communication through PC hyper terminal
- Connector (labeled as P1) for Flash programming using the IAR J-Link debug probe

The STM32W108 application board (MB851) can be powered as follows:

- Power via batteries (place jumper on pins 1-2 on connector P3)
- Power via JTAG (place jumper on pins 3-4 on connector P3)
- Power via USB (place jumper on pins 5-6 on connector P3)

Figure 1. STM32W108 application board

2.1.3 JTAG adaptation board (MB885)

This adapter board is used for connecting an IAR™ J-Link to the STM32W108 microcontroller through the P1 board connector for STM32W108 Flash programming and debugging operations.

2.1.4 IAR J-Link debug probe

For detailed information about the IAR J-Link USB-JTAG/SWD debug probe, please refer to the www.iar.com website.

2.2 Software overview

This section describes the software components delivered with the EmberZNet stack for the STM32W108 microcontroller.

2.2.1 EmberZNet ZigBee PRO stack

The EmberZNet™ ZigBee PRO compliant networking stack is an advanced wireless protocol stack that runs on the STM32W108 RF microcontroller and provides algorithms for creating reliable, flexible and secure networks.

For information about the EmberZNet™ ZigBee stack, see the related documentation in your kit.

2.2.2 Hardware abstraction layer (HAL)

HAL APIs enable addressing certain STM32W108 platform devices and capabilities (buttons, LEDs, memory, microcontroller, system timer, UART …).

2.2.3 ZigBee PRO application utility APIs

A collection of useful functions used in STM32W108 ZigBee starter kit (beta version) sample applications and for common ZigBee tasks that a customer may wish to re-use in his custom project:

- Command-line-interface (CLI) — (*app/util/serial/cli.[ch]*)
  A simple command interpreter for processing serial input and calling application functions
- Counters — (*app/util/counters.[ch]*)
  Implements emberCounterHandler() and keeps a tally of the events reported by the stack.
- Form-and-join — (*app/util/common/form-and-join.[ch]*)
  Supports scanning for forming and joining networks.
- Fragment — (*app/util/zigbee-framework/fragment**)
  Breaks long messages into smaller blocks for transmission and reassembles received blocks.
- Inter-PAN — (*app/util/zigbee-framework/ami-inter-pan**)
  Utilities for sending and receiving ZigBee AMI InterPAN messages.
- Network manager — (*app/util/zigbee-framework/network-manager**)
  Utilities for use by the ZigBee network manager
- Print stack tables — (*app/util/common/print-stack-tables.[ch]*)
  Functions to print stack tables for use in troubleshooting.
- Security — (*app/util/security/**)
  Implementation for setting up security on a Trust Center device and a non Trust Center device.
- Serial — (*app/util/serial/serial.[ch]*)
  The high-level serial drivers used by the stack for I/O processing.
- Source-route — (*app/util/source-route**)
  Example code for managing source routes on a gateway.

- ZigBee cluster library (ZCL) — (*app/ha/zcl-util**)
  An implementation of the ZCL. See also the reference application in this directory.
- ZigBee device object (ZDO) TX functions — (*app/util/zigbee-framework/zigbee-device**)
  The ZDO library provides functions that construct and send several common ZDO requests. It also provides a function for extracting the two addresses from a ZDO address response.

2.2.4 ZigBee PRO demo applications

The following demo applications and utilities library are provided:

- Sink & Sensor
- Nodetest application
- Smart Energy / Home Automation (SE / HA)
- ZigBee Device Object (ZDO) sample
- Manufacturing Library sample (mfg-sample-app)

2.2.5 Daintree sensor network analyzer

The Daintree Sensor Network Analyzer (SNA) combines a powerful protocol analyzer with network visualization, measurements and diagnostics for IEEE 802.15.4 and ZigBee® applications. It provides automatic display of network formation, topology changes, and router and coordinator state changes allowing rapid detection of incorrect network behavior and identification of device or network failures.

The STM32W108 ZigBee® starter kit (beta version) includes an evaluation version of Daintree Sensor Network Analyzer which allows customer to use the standard edition of software for a period of 30 days. After this time, customers can upgrade directly from Daintree. In any case, the SNA Basic Edition remains available. SNA customer support is handled by Daintree.

2.2.6 Daintree capture firmware

To enable use of the Daintree Sensor Network Analyzer, special firmware is required for configuring the STM32W108 application board (MB851) as a Daintree capture device (a starter kit board is already preprogrammed with the Daintree capture firmware). This device is included in this kit.

2.2.7 IAR compiler

The IAR Embedded Workbench IDE for ARM is a very powerful Integrated Development Environment (IDE) designed for developing and managing complete embedded applications projects.

The provided IAR 5.30 version requires a patch for adding support for the STM32W108. (The STM32W108 is on the way to be supported by an official IAR release). For detailed information about IAR products, please refer to the www.iar.com website.

3 ZigBee PRO application descriptions

3.1 Sink and sensor applications

An example of a complete application that implements a distributed sensors network with 1 or more data collection points (called “sensors”) and 1 data storage point (called “sink”). Each Sink broadcasts its identity via a multicast message (SINK_ADVERTISE) to nearby Sensor nodes, who can then set up an entry into their address table to the Sink and send a request (the SENSOR_SELECT_SINK message) for attachment to that Sink. If the Sink agrees to accept data from a particular Sensor, the Sensor receives a confirmation message (SINK_READY) and begins transmitting data reports (DATA) to the Sink at fixed intervals (as set by SEND_DATA_RATE).Sleepy and mobile sensors nodes are also supported.

Roles:

- Sensor — A device that takes data readings from some input source and passes these readings to a particular collection point. Many Sensors report to a single Sink.
- Sink — A device that serves as a collection point for 1 or more Sensor devices. In this example, the Sink is set up to be the ZigBee Coordinator device, and it forms the network automatically on first startup and retains this settings across reboots. (See Notes section below if wanting to use multiple Sinks in a network.)
- Sleepy-Sensor — A sleeping version of the Sensor application. Battery powered devices must sleep in order to extend their battery life.
- Mobile-Sensor — A sleeping and mobile version of the Sensor application.

Buttons used

- Sensor:
  - S1 button: If the device is not joined to a network, pressing this causes the device to search for an available network and join it if possible. After it has successfully joined a network, pressing this button will cause the device to permit joining (accepting other devices into the network) for the next 60 seconds.
  - RST button: Forces the device to reset. This can be useful if you have left the network and now want the device to attempt network participation again. (Note that if you have not left the network before resetting, the device will simply resume operation on the same network as before.)
- Sink:
  - S1 button: After network formation, pressing this button allows joining to the network by other devices for the next 60 seconds.
  - RST button: Forces the device to reset. This can be useful if you have left the network and now want the device to establish a new network. (Note that if you have not left the network before resetting, the device will simply resume operation on the same network as before.)

Serial baud rates, ports used

- 115200 bps for all devices

Serial commands supported

Table 1. List of supported commands

Command	Description
f	Forces the sink to advertize. (Sink only)
p	Prints the binding table of the node.
l	Tells the node to send a multicast hello packet.
i	Prints info about this node including channel, power, and app.
b	Puts the node into the bootloader menu (as an example).
0	Simulates S1 button press. Turns `permit join` on for 60 seconds, allowing other nodes to join to this node.
1	Simulates RST button press. Resets this node.
x	Prints token information (non-volatile settings stored in EEPROM).
c	Prints child table. (Sensor and Sink only)
j	Prints status of Just In Time (JIT) message storage. (JIT messages are used to communicate reliably with sleeping end devices.)
a	Prints the status of `emberNetworkState`, `emberOkToNap`, `emberOkToHibernate`, and `emberCurrentStackTasks`. The app must be built with `DEBUG_NETWORK_STATE`. (Used for debugging.)
?	Prints the help menu.

3.1.1 Notes and limitations

This application defaults to using a fixed set of network parameters, with a default channel setting of 26. (Remove the `#define USE_HARDCODED_NETWORK_SETTINGS` line in the common.h header file to allow the application to dynamically select its network parameters.)

Although the example portrays a single Sink node that acts as a ZigBee Coordinator, the application could be easily adapted to allow a variant of the Sink node that joins the network as an ordinary ZigBee Router so that multiple Sinks can be supported.

Although the example is set up to have a Sensor node participate in the network as a ZigBee Router, the application could support Sensors as sleepy or mobile ZigBee End Devices as well.

This application uses a “push” style of communication, where the Sensor sends reports to the Sink without needing to be asked for this data. This is more efficient than a “pull” model, where a device only transmits data when asked to do so by another device, because it cuts the amount of traffic in half, thereby reducing the number of collisions and routing burden in the network.

The data reports used in this example are fixed size packets (of a size defined by `SEND_DATA_SIZE`). The data contents are simply a 16-bit random pattern (generated for each message) that is repeated as many times as necessary to fill the packet to its required size.

The application uses a constant called `MISS_PACKET_TOLERANCE` as a threshold for fault tolerance. On the Sensor, this controls how many message timeouts can be permitted between the Sensor and Sink before the Sensor decides to attach itself to a different Sink.

For a Sink, this controls how many data reports can be missed from a Sensor before the Sink “forgets” about the Sensor (stops maintaining a record of its attachment). Although bindings are kept on the Sink node to track the attached Sensors, these could easily be made temporary (used only for the `SINK_READY` message) to allow the Sink application to support more nodes without enlarging the binding table, assuming that the Sink application does not care which Sensors and how many Sensors are attached to it.

This application is designed to scale to approximately 250 sensors and one sink. The applicability of this in large networks is dependant on the traffic rates expected from sensors to sink. Suitable jitter needs to be sensor data reports to ensure traffic is spread out to avoid bottlenecks around the sink.

The sensor advertisement is a broadcast. The behavior of such a broadcast in the network depends on the network topology and density. Zigbee limits the number of broadcasts that can be active in a network to 10 to minimize the network disruption and loss of bandwidth. As this network increases in size or density, the rate of the sensor advertisement should be reduced in frequency.

3.2 Nodetest application

It is a low-level test program meant for functional testing of RF modules, including token viewing/programming, range testing, RSSI measurement, and special test modes of transmission as required for FCC and CE certification.

Roles

- Device Under Test (DUT) — The primary device undergoing functional testing. You will probably want to also load Rangetest to a node that you are sure is working correctly (often called the “Golden Node”) so that you can verify proper communication and comparison between the DUT and the Golden Node when each are running Rangetest.

Buttons used

- None

Serial baud rates, ports used

- The Rangetest runs at 115200 bps. Active serial port is auto-detected; whichever of the UART or virtual UART first detects a Carrier Return (\r), Line Feed (\n), or asterisk ('*') character will become the port used until the application is reset.

Serial commands supported

This application supports different commands depending on the hardware platform being used. Use the `HELP` or `?` command to list all supported commands on the current device's platform.

3.2.1 Notes and limitations

This application is provided in pre-built form only.

The packets transmitted by Rangetest are raw packets sent by the radio without the aid of a networking stack, so 802.15.4 and ZigBee conventions, such as CSMA-CA algorithms, random backoffs, transmission retries and MAC and Network Layer packet headers, do not apply in this context. Such test conditions can produce very different results when comparing reliability of communication to a test case involving two (or more) devices running a full ZigBee networking stack. Therefore, it is recommended that you perform interference testing, coexistence testing and reliability testing with your own application

(based on the networking stack) in addition to any similar testing done with Rangetest, so that your results are more representative of a true networking scenario.

Packets transmitted by Rangetest are of a fixed size (the minimum size allowed by the radio) and are always transmitted at a fixed rate. (This rate may be different for different radios; see program output for details.)

This application is not intended for use in operating networks. Use by nodes in a network will result in packet collisions and lost traffic. This application can be used by multiple nodes at the same time where one node sends packets and multiple other nodes receive the traffic.

3.3 Smart energy (SE) / home automation (HA)

The Smart Energy (SE) / Home Automation (HA) profile provides the Application Framework that can be setup to implement ZigBee Smart Energy devices or ZigBee Home Automation devices. This includes an implementation of the ZigBee Cluster Library which enables building any of the SE or HA devices.

Roles:

- SE Energy Service Portal (ESP) - implements the clusters for an SE ESP
- SE Meter - implements the clusters for an SE Meter
- SE Smart Appliance (SA)

Note: Other HA, SE or custom ZigBee device types can be built by adding the proper `#defines` *to include the correct clusters.*

Button used

- S1 button: If not joined: FORM (if the device is capable of forming).
  If joined: BIND (send ZDO end device bind request).

Serial baud rates, ports used

- Default baud rate is 115200 bps for all devices.
- This can be set to 9600, 19200, 38400, or 115200 baud rate by changing the `ZA_BAUD_RATE` value.

3.3.1 Serial commands

General commands

Table 2. List of general commands

Command	Description
`help`	Lists the available commands.
`version`	Shows the version of the software.
`reset`	Resets the device.
`option button0`	Simulates a `S1 button` press.

Table 2. List of general commands (continued)

Command	Description
`option button1`	Simulates a `RST button` press.
`write [cluster] [attrID] [dataType] [dataLen] [bytes 0-7] [bytes 8-15]`	Writes the value specified to the attribute specified in the local attribute table where: `cluster`, cluster identifier in decimal format `attrID`, attribute identifier in decimal format `dataType`, data type as a 2-character string in decimal format `dataLen`, data length (variable) in decimal format `bytes 0-7`, in hexadecimal format `bytes 8-15`, in hexadecimal format

Informational commands

Table 3. List of informational commands

Command	Description
`info`	Gives information about the local node.
`option binding-table print`	Prints the binding table.
`option binding-table clear`	Clears the binding table.
`keys`	Prints the APS Link Key table.
`print attr`	Prints the ZCL attribute table.
`print identify`	Prints the identify cluster state.
`print groups`	Prints the groups table.
`print scenes`	Prints the scenes table.
`print c (ias-ace info)`	Prints the ias-ace info.
`print price`	Prints the Price table showing the currently configured prices.
`print message`	Prints the Message table, showing the currently configured or received messages.
`print time`	Prints the current time.
`print report`	Prints the reporting table.

Network commands

Table 4. List of network commands

Command	Description
`network form [channel] [power] [panid]`	Starts a ZigBee network with: `channel`, channel number (11 to 26) in decimal format `power`, radio transmit power value in decimal format `panid`, PAN identifier as a 4-character hexadecimal string Example, "`network form 11 2 0abb`"
`network pjoin [time]`	Sets time joining is permitted on a ZigBee network with: `time, in seconds in decimal format`
`network join [channel] [power] [panid]`	Attempts to join a ZigBee network with: `channel`, channel number (11 to 26) in decimal format `power`, radio transmit power value in decimal format `panid`, PAN identifier as a 4-character hexadecimal string The device uses `ZA_DEVICE_TYPE` when joining. If type is Coordinator, it joins as a Router. Example, "`network join 11 2 0abb`"
`network leave`	Forces node to exit current ZigBee network.
`network extpanid [extpanid value]`	Sets the extended PAN ID used for forming or joining a network. This must be done before a device becomes part of a network, where: `extpanid value` is a 16 character (8 byte) hexadecimal string representing the extended PAN ID desired.
`option disc [clusterId]`	Sends a ZDO Match Descriptor Request for the server side of the cluster specified. Match Descriptor Responses received are printed to the serial output. `clusterId`, is a 4 character (2 byte) hexadecimal string.
`option edb`	Sends a ZDO End Device Bind Request using the local endpoint specified by `ZA_GLOBAL_SRC_ENDPOINT`.

Security commands

Table 5. List of security commands

Command	Description
`keys`	Prints the APS Link Key table.
`keys clear`	Clears the APS Link Key table.
`option link [index] [EUI64] [key bytes 0-7] [key bytes 8-15]`	Sets a link key in the link key table, where: `index`, in key table `EUI64`, in big endian format `key bytes 0-7`, in hexadecimal format `key bytes 8-15`, in hexadecimal format

Table 5. List of security commands (continued)

Command	Description

`option register [nodeId] [endpoint] [EUI]`	Initiates Smart Energy Key Establishment using the nodeId, endpoint, and EUI passed in the command, where:
	`nodeId`
	`endpoint`
	`EUI`
	(Available only when using Smart Energy Security.)

`option partner [partner EUI]`	Initiates a partner link key request to the Trust Center, where: `partner EUI,` (Available only when using Smart Energy Security.)

Commands for building and sending messages

Table 6. List of commands for building and sending messages

Command	Description
`send [id] [src] [dst]`	Sends a message using the message that exists in the current send buffer (created using “zcl” command), where: `id`, is the node identifier as a 4-character hexadecimal string `src`, is the source endpoint in decimal format `dst`, is the destination endpoint in decimal format
`bsend [src]`	Sends the current message to any device in the binding table that has a binding entry with a cluster matching the cluster specified in the message, where: `src`, is the source endpoint in decimal format
`timesync [id] [src] [dst]`	Sync time with the device specified by sending a read attribute command and using the read attribute response, where: `id`, is the node identifier as a 4-character hexadecimal string `src`, is the source endpoint in decimal format `dst`, is the destination endpoint in decimal format
`anon short [id] [short dest panid] [dest app-profile-id]`	Sends an Inter-PAN message using the message that exists in the send buffer (created with “zcl” command) to the shortID specified on the destination PAN specified and using the Application Profile specified, where: `id`, is the node identifier as a 4-character hexadecimal string `short dest panid`, is a 4-character hexadecimal string `dest app-profile-id`, is a 4-character hexadecimal string

Table 6. List of commands for building and sending messages (continued)

Command	Description
`raw1 [clusterID] [len] [data 0-8] [data 9-16] [data 17-24] [data 25-32]`	Creates a message by specifying the raw bytes, where: clusterID, in decimal format `len`, is the message length in decimal format `data 0-8`, in hexadecimal format `data 9-16`, in hexadecimal format `data 17-24`, in hexadecimal format `data 25-32`, in hexadecimal format To specify messages larger than 32 bytes use this command first and then use `"raw2"`. Use `"send"` to send the message once it has been created. Example, "`raw1 15 8 000A001122334455`" sends a message to cluster 15 (0xF) of length 8 which includes the ZCL header.
`raw2 [clusterID] [len] [data 33-40] [data 41-48] [data 49-56] [data 57-64]`	Specifies bytes 33 through 64 of a message, where: `len`, is the message length in decimal format `data 33-40`, in hexadecimal format `data 41-48`, in hexadecimal format `data 49-56`, in hexadecimal format `data 57-64`, in hexadecimal format The first 32 bytes are set using the "`raw1`" command.

ZCL Global serial commands

Note: These commands construct a payload, you must call "send" to send the message.

Table 7. List of ZCL global serial commands

Command	Description
`zcl global read [cluster] [attrID]`	This command reads the specified attribute, where: `cluster`, in decimal format `attrID`, as a 4-character hexadecimal string
`zcl global write [cluster] [attrID] [data type] [data]`	This command writes the specified attribute, where: `cluster`, in decimal format `attrID`, as a 4-character hexadecimal string `data type`, as 2-character hexadecimal string `data`, variable size depending on `data type` as a hexadecimal string
`zcl global uwrite [cluster] [attrID] [data type] [data]`	This command changes the values of one or more attributes located on another device, in such a way that if any attribute cannot be written, no attribute values are changed, where: `cluster`, in decimal format `attrID`, as a 4-character hexadecimal string `data type`, as 2-character hexadecimal string `data`, variable size depending on `data type` as a hexadecimal string

Table 7. List of ZCL global serial commands (continued)

Command	Description
`zcl global nwrite [cluster] [attrID] [data type] [data]`	This command changes the value of one or more attributes located on another device but does not require a response, where: `cluster`, in decimal format `attrID`, as a 4-character hexadecimal string `data type`, as 2-character hexadecimal string `data`, variable size depending on `data type` as a hexadecimal string
`zcl global discover [cluster] [attrID] [max # to report]`	This command is used to discover the identifiers and types of the attributes on a device, where: `cluster`, in decimal format `attrID`, as a 4-character hexadecimal string `max # to report`, in decimal format
`zcl global report-read [cluster] [attrID] [direction]`	This command is used to read the configuration details of the reporting mechanism for one or more of the attributes of a cluster, where: `cluster`, in decimal format `attrID`, as a 4-character hexadecimal string `direction`, in decimal format (‘0’ for client-to-server, ‘1’ for server to client)
`zcl global send-me-a-report [cluster] [attrID] [data type] [min report time] [max report time] [reportable change]`	This command replies to a `zcl global report-read` command, where: `cluster`, in decimal format `attrID`, as a 4-character hexadecimal string data type, as 2-character hexadecimal string `min report time`, in seconds as a 4-character hexadecimal string `max report time`, in seconds as a 4-character hexadecimal string `reportable change`, variable size depending on `data type` as a hexadecimal string
`zcl global expect-report-from-me [cluster] [attrID] [timeout]`	This command is used by a device to report the values of one or more of its attributes to another device, where: `cluster`, cluster identifier in decimal format `attrID`, attribute identifier as a 4-character hexadecimal string `timeout`, in decimal format

ZCL cluster-specific serial commands

Many of these commands build cluster-specific messages that can be sent with the “send” command.

Note: 1 These commands construct a payload, you must call “send” to send the message.

2 These commands are available on a per-cluster basis and the application must have defined the client (or server) side of the cluster to have access to these commands.

3 The send command must be followed by the short address to which the message should be sent.

Example:

```
on-off-client> zcl on-off off
on-off-client> send 0
ias-zone-server> zcl ias-zone enroll
ias-zone-server> send 05c7
```

Table 8. List of ZCL cluster-specific serial commands

Command	Description
ZCL Basic Client commands	
`zcl basic rtfd`	This command is used to reset all the attributes of all its clusters of a device to their factory default values.
ZCL Identify Client commands	
`zcl identify id [identify time]`	This command specifies the remaining length of time the device will continue to identify itself, where: `identify time`, in seconds as 4-character hexadecimal string
`zcl identify query`	This command allows the sending device to request the target or targets to respond if they are currently identifying themselves.
ZCL Identify Server commands	
`zcl identify on [seconds]`	This command turns on the identify on the local device for the number of seconds specified, where: `seconds`, in seconds in decimal format
`zcl identify off`	This command turns off identify on the local device.
ZCL Groups Client commands	
`zcl groups add [groupId] [name]`	This command adds a device to a group, where: `groupId`, group identifier as 4-character hexadecimal string `name`, as 16 character ASCII string
`zcl groups view [groupId]`	This command requests to view group name, where: `groupId`, group identifier as 4-character hexadecimal string
`zcl groups get [count] [[groupId]`	This command requests a list of group memberships of a device, where: `count`, in decimal format `groupId`, group identifier as 4-character hexadecimal string
`zcl groups remove [groupId]`	This command removes a device from a group, where: `groupId`, as 4-character hexadecimal string
`zcl groups rmall`	This command removes all group associations for a device.
`zcl groups ad-if-id [groupId] [name]`	This command adds group membership for a device if it is identifying itself, where: `groupId`, group identifier as 4-character hexadecimal string `name`, as 16-character ASCII string

Table 8. List of ZCL cluster-specific serial commands (continued)

Command	Description
ZCL Scenes Client commands	
`zcl scenes add [groupId] [sceneId] [transition time] [name]`	This command adds a scene, where: `groupId`, group identifier as 4-character hexadecimal string `sceneId`, scene identifier as 2-character hexadecimal string `transition time`, in seconds as 4-character hexadecimal string `name`, as 16-character ASCII string
`zcl scenes view [groupId] [sceneId]`	This command displays scene information, where: `groupId`, group identifier as 4-character hexadecimal string `sceneId`, scene identifier as 2-character hexadecimal string
`zcl scenes remove [groupId] [sceneId]`	This command removes a scene, where: `groupId`, as 4-character hexadecimal string `sceneId`, as 2-character hexadecimal string
`zcl scenes rmall [groupId]`	This command removes all scenes from the Scene table for all devices with this Group ID, where: `groupId`, group identifier as 4-character hexadecimal string
`zcl scenes store [groupId] [sceneId]`	This command adds an entry to the Scene table, where: `groupId`, group identifier as 4-character hexadecimal string `sceneId`, scene identifier as 2-character hexadecimal string
`zcl scenes recall [groupId] [sceneId]`	This command locates the entry in the Scene table, where: `groupId`, group identifier as 4-character hexadecimal string `sceneId`, scene identifier as 2-character hexadecimal string
`zcl scenes get-membership [groupId]`	This command is used to find an unused scene number, where: `groupId`, group identifier as 4-character hexadecimal string
`zcl scenes set ["on" or "off" keyword] [level value]`	This command sets the scene extensions for on/off and level control, where: `"on"` or `"off"` keyword `level value`, as integer
ZCL On/Off Client commands	
`zcl on-off off`	This command switches off a device.
`zcl on-off on`	This command switches on a device.
`zcl on-off toggle`	This command toggles the device state (on or off).
ZCL Level Control Client commands All arguments are given in hexadecimal format. The value listed after an argument is the number of bytes it expects. The number of characters expected are 2 times that number.	
`zcl level-control mv-to-level [level:1] [transition time:2]`	This command is used to have a device move to a new level in the specified time, where: `level`:1 `transition time`:2

Table 8. List of ZCL cluster-specific serial commands (continued)

Command	Description
`zcl level-control move [mode:1] [rate:1]`	This command defines the direction and rate of movement of level change, where: `mode`:1 `rate`:1
`zcl level-control step [step:1] [step size:1] [trans time:2]`	This command defines the time to perform the step, in tenths of a second, where: `step`:1 `step size`:1 `trans time`:2
`zcl level-control stop`	This command cancels all on-going level change operations.
`zcl level-control o-mv-to-level [level:1] [trans time:2]`	This command performs the Move to Level command with the On/Off feature, where: `level`:1 `transition time`:2
`zcl level-control o-move [mode:1] [rate:1]`	This command performs the Move command with the On/Off feature, where: `mode`:1 `rate`:1
`zcl level-control o-step [step:1] [step size:1] [trans time:2]`	This command performs the Step command with the On/Off feature, where: `step`:1 `step size`:1 `trans time`:2
ZCL Time Server commands	
`zcl time [year] [month] [day] [hour] [min] [sec]`	This command sets the local time to the value specified, where: all arguments in decimal.
ZCL Thermostat Client commands	
`zcl tstat set [mode] [amount]`	This command configures the thermostat, where: `mode`, Heat, Cool or Both as 2-character hexadecimal string `amount`, as 2-character hexadecimal string
ZCL IAS Zone Server commands	
`zcl ias-zone enroll [zone type] [manuf]`	This command sets a device for operation in a zone, where: `zone type`, as 4-character hexadecimal string `manuf code`, device manufacturer code as 4-character hexadecimal string
`zcl ias-zone sc [zone status] [extended status]`	This command indicates a change in the zone status, where: `zone status`, as 4-character hexadecimal string `extended status`, as 2-character hexadecimal string
ZCL IAS ACE Client commands	
`zcl ias-ace arm [mode]`	This command sets the device Arm mode, where: `mode`, as 2-character hexadecimal string

Table 8. List of ZCL cluster-specific serial commands (continued)

Command	Description
`zcl ias-ace bypass [numZones] [zones:numZones zones]`	This command is used to bypass the Arm mode, where: `numZones`, as 2-character hexadecimal string `zones: numZones zones`, as 2-character hexadecimal string
`zcl ias-ace emergency`	This command indicates an emergency situation.
`zcl ias-ace fire`	This command indicates a fire situation.
`zcl ias-ace panic`	This command indicates a panic situation.
`zcl ias-ace getzm`	This command is used to get a zone ID map.
`zcl ias-ace getzi [zoneID]`	This command is used to get a zone ID, where: `zoneID`, as 2-character hexadecimal string
ZCL Price Client commands	
`zcl price current [command options]`	This command initiates a Publish Price command for the current time, where: `command options`, the Requestor Rx On When Idle value which could be '0' or '1'.
`zcl price scheduled [num events requested]`	This command initiates a Publish Price command for all currently scheduled times, where: `num events requested`, as 2-character hexadecimal string
ZCL Price Server commands These commands are used for configuring Prices in the Price table on the ESP. The Price table can be viewed by using "print price"	
`zcl set-price clear`	
`zcl set-price current [index]`	This command sets the index entry with the current time.
`zcl set-price [index] [providerID] [label] [eventId]`	This command sets the index entry with the providerID, label and eventId, where: `index`, in decimal format `providerID`, as 8-character (4 byte) hexadecimal string `label`, as up to 13-character ASCII string `eventId`, as 8-character (4 byte) hexadecimal string
`zcl set-price [index] [unitOfMeas] [currency] [ptd] [PTRT]`	This command sets the index entry with unitofMeas, currency, ptd and PTRT, where: `index`, in decimal format] `unitOfMeas`, as 2-character (1 byte) hexadecimal string `currency`, currency symbol to display as 4-character (2 byte) hexadecimal string `ptd`, price trailing digit as 2-character (1 byte) hexadecimal string `PTRT`, Price Tiers & Register Tier value as 2-character (1 byte) hexadecimal string

Table 8. List of ZCL cluster-specific serial commands (continued)

Command	Description
`zcl set-price [index] [startTime] [duration]`	This command sets the index entry with startTime and duration, where: `index`, in decimal format `startTime`, as 8-character (4 byte) hexadecimal string `duration`, a 4-character (2 byte) hexadecimal string
`zcl set-price [index] [price] [ratio] [genPrice] [genRatio]`	This command sets the index entry with price, ratio, genPrice and genRatio, where: `index`, in decimal format] `price`, as 8-character (4 byte) hexadecimal string `ratio`, as 2-character (1 byte) hexadecimal string `genPrice`, as 8-character (4 byte) hexadecimal string `genRatio`, as 2-character (1 byte) hexadecimal string
`zcl sprice publish`	This command sets up an unsolicited publish price command.
ZCL Demand Response Load Control Server commands	
`zcl drlc lce [eventId] [start time] [duration] [event control]`	This command constructs a Load Control Event, where: `eventId`, as 8-character (4 byte) hexadecimal string `start time`, as 8-character (4 byte) hexadecimal string `duration`, in minutes as 4 character (2 byte) hex string `event control`, as 2-character (1 byte) hexadecimal string
`zcl drlc cl [eventId] [start time]`	This command cancels a Load Control Event, where: `eventId`, event identifier as 8-character (4 byte) hexadecimal string `start time`, as 8-character (4 byte) hexadecimal string
`zcl drlc ca`	This command cancels all Load Control Events.
ZCL Demand Response Load Control Client commands	
`zcl drlc gse [number of events to get]`	This command gets Scheduled Events, where: `number of events to get`, as 2-character (1 byte) hexadecimal string
`zcl drlc opt in`	This command opts in to current DRLC event.
`zcl drlc opt out`	This command opts out of current DRLC event.
ZCL Simple Metering Client commands	
`zcl sm gp [type] [time] [intervals]`	This command gets a profile, where: `type`, as 2-character (1 byte) hexadecimal string `time`, as 8-character (4 byte) hexadecimal string `intervals`, as 2-character (1 byte) hexadecimal string
ZCL Simple Metering Server commands These commands are used on an ESP or a Meter to simulate the behavior of a meter.	
`zcl tm print`	This command prints the state of the Test Meter setup.
`zcl tm [electric | gas | off]`	This command sets the Test Meter mode, where: `electric` or `gas` turn the test mode on `off` turns the test mode off.

Table 8. List of ZCL cluster-specific serial commands (continued)

Command	Description
`zcl tm rate [consumption rate]`	This command sets the normal consumption rate per second, where: consumption rate in decimal
`zcl tm variance [variance]`	This command sets a variance to add to the normal consumption rate each second, where: `variance`, in decimal format If the consumption rate is set to 2 and variance is set to 3 the consumption rate will be between 2 and 5 units per second. The actual number is randomly chosen.
`zcl tm adjust`	This command adjusts the consumption of the meter based on the time value as if the device was consuming at the currently set rate and variance for the whole of the current day.
ZCL Messaging Client commands	
`zcl message get`	This command sends a get last message command.
ZCL Messaging Server commands	
`zcl message display`	This command sends a display message using the current message.
`zcl message cancel`	This command sends a cancel message using the current message.
The following commands are for setting the message on the Messaging Server.	
`zcl set-message message [message]`	This command defines a message, where: `message`, up to 16 ASCII character string
`zcl set-message append [message]`	This command adds additional text to a message, where: `message`, up to 16 ASCII character to append to the current message
`zcl set-message id [messageId]`	This command sets the current message identifier, where: `messageId`, as 8-character (4 byte) hexadecimal string
`zcl set-message time [start time] [duration]`	This command sets the time for the message, where: `start time`, as 8-character (4 byte) hexadecimal string `duration`, as 4 character (2 byte) hex string
`zcl set-message transmission [normal|ipan|both]`	This command sets the message transmission type.
`zcl set-message importance [low|med|high|critical]`	This command sets the message level of importance.
`zcl set-message confirm [true|false]`	This command defines if the message confirmation is required.
`zcl set-message cancel`	This command provides the ability to cancel the sending or the acceptance of previously sent messages.

3.3.2 Notes and limitations

This application uses #defines to enable pieces of the application code. See app/ha/ha-config.h for examples of the #defines that can be used. A device is defined by the clusters it supports, so the base of the application stays the same and the clusters supported changes. Supporting a client-side of a cluster enables the serial commands for that cluster. Supporting the server-side of a cluster defines the attributes in the attribute table and support for receiving messages generated by the client.

3.4 ZigBee device object (ZDO) sample

The ZDO application sample provides an example of how to send ZDO messages using the ZDO library.

Roles

- ZDO Test Device

Buttons used

- None

Serial baud rates, ports used

- 115200 bps for all devices

Serial commands supported

Table 9. List of supported commands

Command	Description
`help`	Prints the help menu.
`version`	Prints the version of the application.
`info`	Prints info about this node including channel, power, and app information.
`network`	Network commands: `form`, `join`, `leave` and `permit join`.
`zdo`	Sends ZDO commands. See help for more info.
`print`	Prints the binding table.
`reset`	Resets the node.

3.4.1 Notes and limitations

This is meant as a simple example of using the ZDO Library calls and is not designed as a fully featured application.

3.5 Manufacturing library sample

The manufacturing library sample application provides an example of how to use the manufacturing library.

Roles

- Manufacturing Library Device

Buttons used

- None

Serial baud rates, ports used

- 115200 bps for all devices

Serial commands supported

Table 10. List of supported commands

Command	Description
`help`	Displays the list of available commands.
`version`	Displays the software version.
`info`	Displays information about the local node.
`reset`	Resets the device.
`network form [channel] [power] [panid]`	Starts a ZigBee network with: `channel`, channel number (11 to 26) in decimal format `power`, radio transmit power value in decimal format `panid`, PAN identifier as a 4-character hexadecimal string
`network join [channel] [power] [panid]`	Attempts to join a ZigBee network with: `channel`, channel number (11 to 26) in decimal format `power`, radio transmit power value in decimal format `panid`, PAN identifier as a 4-character hexadecimal string
`network leave`	Leaves current ZigBee network.
`network pjoin [time]`	Sets time joining is permitted on a ZigBee network with: `time`, in seconds in decimal format
`network`	
`mfg start [want callback, 0=False, 1=True]`	`[want callback, 0=False, 1=True]`
`mfg end`	
`mfg tone start`	
`mfg tone stop`	
`mfg stream start`	
`mfg stream stop`	
`mfg send [numPackets] test-packet [length]`	`[numPackets]` `[length]`
`mfg send [numPackets] random [length]`	`[numPackets]` `[length]`

Table 10. List of supported commands (continued)

Command	Description
`mfg send [numPackets] message [first 8 bytes] [second 8 bytes]`	`[numPackets] [first 8 bytes] [second 8 bytes]`
`mfg chan set [channel]`	`[channel]`
`mfg chan get`	
`mfg power set [power]`	`[power]`
`mfg power get`	

3.5.1 Notes and limitations

This is meant as a simple example of using the Manufacturing Library calls and is not designed as a fully featured application.

4 Getting started

This section provides a complete description on how to use the kit and how to setup the required hardware and build, run the ZigBee demo applications. It also provides information about how to set up and use the Daintree Sensor Network Analyzer.

4.1 Kit setup

4.1.1 EmberZNet for STM32W108 software installation

Currently, the EmberZNet 4.0.0 Alpha3 ZigBee stack for the STM32W108 microcontroller is delivered as a ZIP file to be unzipped in the user's working folder.

4.1.2 Host development platform (IAR toolset)

The IAR Embedded Workbench IDE for ARM toolset (version 5.30 and 5.40 supporting the STM32 ARM Cortex™ M3) is used for building the ZigBee applications.

Note: IAR 5.30 and 5.40 require a patch to support the STM32W108 microcontroller. The IAR patches can be downloaded from the www.st.com/mcu, STM32W website. For instructions about how to apply them, please refer to the related IAR customization technical note for STM32W108 microcontrollers.

4.1.3 Building a ZigBee application for an STM32W108 application board (MB851)

The following steps are required for building one of the ZigBee application demo provided with the EmberZNet4.0.0Alpha3 ZigBee stack for the STM32W108 microcontroller:

1. Power the STM32W108 Application board through the JTAG: P3 jumper fitted on 3-4 position.
2. Connect the IAR J-Link adapter board (MB885) to the STM32W108 MB851 P1 connector.
3. Connect an IAR J-Link to a PC (through an USB cable) and to the STM32W108 board (through the IAR J-Link adapter board).
4. Open the IAR toolset.
5. From the **File**, **Open**, **Workspace** menu, open the *.eww IAR workspace related to the application you're going to address. The EmberZNet4.0.0Alpha3 IAR *.eww workspace are placed in the specific application directory inside the app folder.
6. From the **View** menu, select **Workspace** to display the supported projects.
7. From the Workspace selector window, select the application configuration related to the Application Board.
8. From the **Project** menu, select **Rebuild All**. A binary file is built in the specific application directory in the build folder.

4.1.4 Download and running a ZigBee application on a STM32W108 application board (MB851)

9. From the **Project** menu, select **Download** and **Debug**. The related binary application is downloaded into the STM32W108 Flash.
10. From the **Project** menu, select **Stop Debugging**.
11. Connect the STM32W108 Application board to the PC USB port (using a USB cable connected to the board mini-USB connector)
12. Open a HyperTerminal on the corresponding USB virtual COMx port with the following configuration:
    - Bit rate: 115200
    - Data bits: 8
    - Parity: None
    - Stop bits: 1
    - Flow control: None

The application is now running.

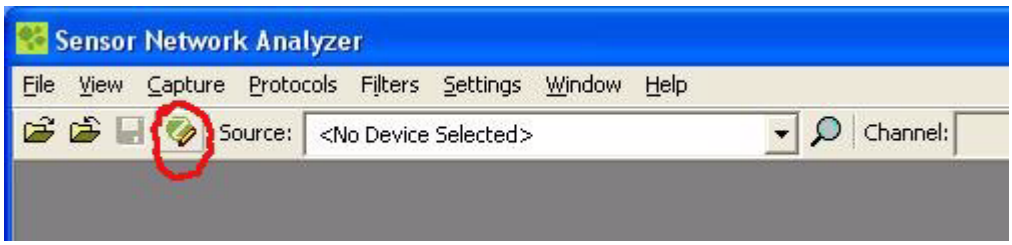
Note: Please follow the same steps for downloading the required image in each node used for building a ZigBee network.

4.1.5 Daintree sensor network analyzer (SNA) setup

When using the Daintree SNA tool, please perform the following steps.

1. Connect the STM32108 MB851 board configured with the Daintree Capture firmware (board labeled as Analyzer) to a PC USB port (P3 jumper in position 5-6). LED D1 (red LED) should be blinking.
2. Open the Daintree SNA tool (previously installed from the provided CD-ROM).
3. Select the Device Manager as shown in *Figure 2*.

Figure 2. Device Manager selection screen shot

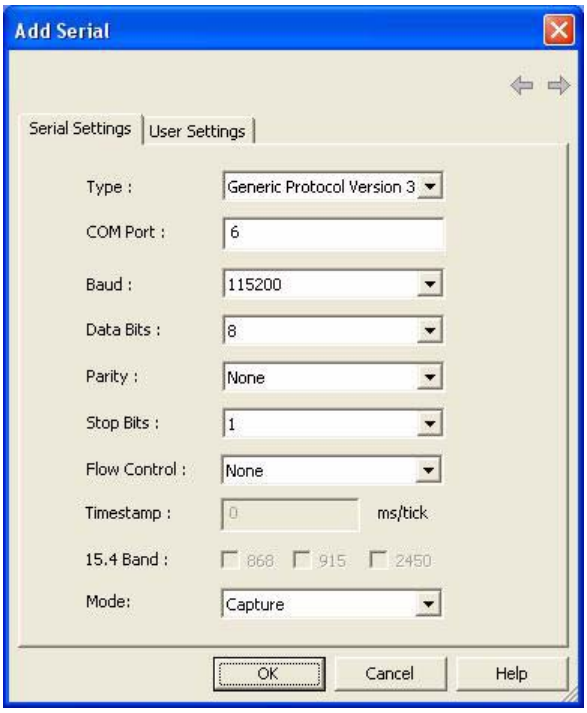


4. Add the serial device as shown in *Figure 3*.

Figure 3. Serial device selection screen shot

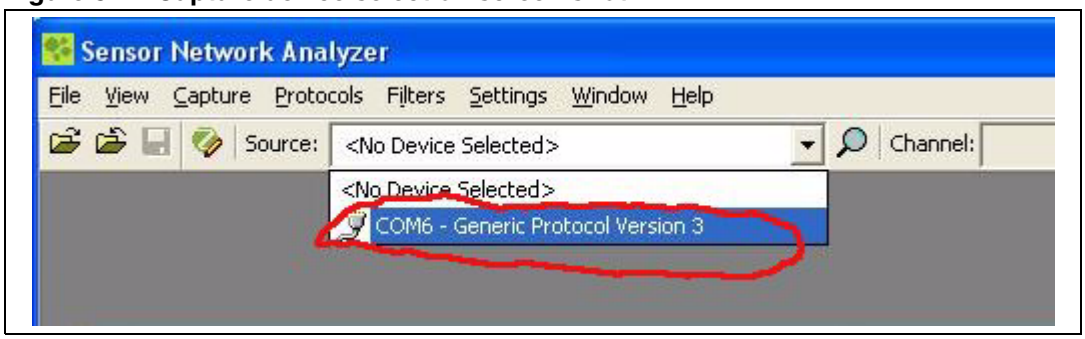
5. Define the serial configuration as shown in *Figure 4*.

Figure 4. Serial configuration screen shot



6. Select the Capture device as shown in *Figure 5*.

Figure 5. Capture device selection screen shot



7. In the SNA main window, select the **Channel** on which you want to capture traffic.
8. From **Capture** menu, select **Start Capture** to start capturing packets on the selected channel.

Note: 1 The sink and sensor demo application set up a network on channel 26. Select 26 as Channel on the Daintree SNA tool for capturing the related packets.

2 In normal operation, the STM32W108 MB851 board configured with the Daintree capture firmware keeps on blinking the red LED (D1) and when a 802.15.4 packet is captured, the green LED (D2) shows a short flash (almost invisible).

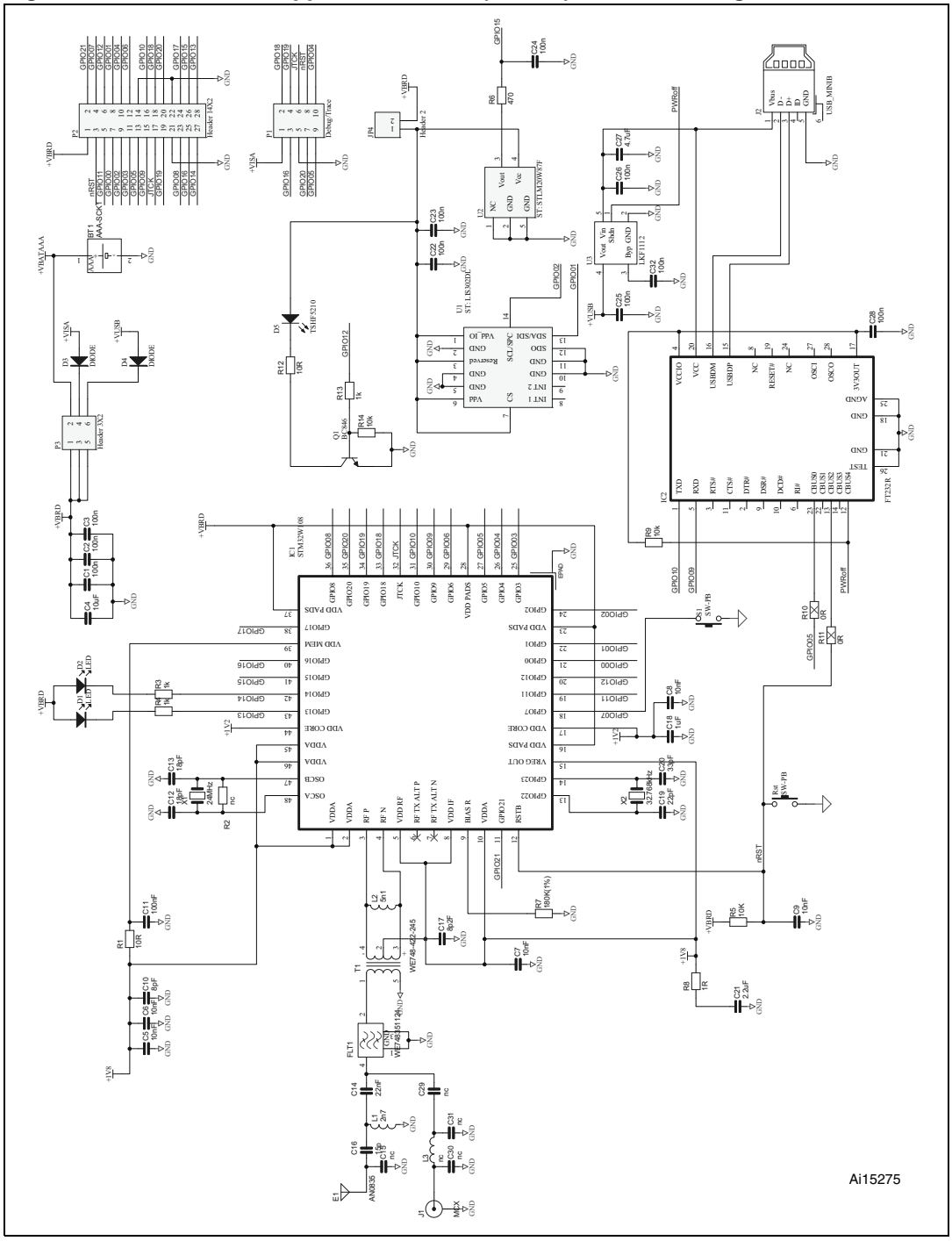
5 Terms and definitions

Table 11. List of terms

Term	Meaning
API	Application programming interfaces
APS	Application Support Sub-Layer
CLI	Command line interface
DUT	Device under test
ESP	Energy Service Portal
EUI	Extended Unique Identifier
HA	Home Automation
HAL	Hardware Abstraction Layer
IAS	Intruder Alarm System
RF	Radio frequency communication
SA	Smart Appliance
SE	Smart Energy
SNA	Sensor Network Analyzer
USB	Universal serial bus
ZCL	ZigBee cluster library
ZDO	ZigBee device object

Appendix A Schematic diagram

Figure 6. STM32W108 application board (MB851) schematic diagram



Appendix B Bill of materials

Table 12. List of components

Marking	Comment	Qty.	Description	Reference	Manu-facturer
BT1	AAA-SCK1	1	2 X AAA battery holder	Generic part	
C1, C2, C3, C11, C22, C23, C24, C25, C26, C28 and C32	100 nF	11	Capacitor ±10%, 25 V, X7R, 0603	Generic part	
C4	10 µF	1	Capacitor	Generic part	
C5, C6, C7, C8 and C9	10 nF	5	Capacitor ±10%, 25 V, X7R, 0603	Generic part	
C10 and C17	8 pF	2	Capacitor 50 V, C0G, NPO, 0402	GRM1555C1H8R0DZ01D	Murata
C12 and C13	18 pF	2	Capacitor ±5%, 50 V, C0G, NPO, 0603	Generic part	
C14	22 nF	1	Capacitor 50 V, C0G, NPO, 0402	Generic part	
C15, C29, C30, C31 and L3	nc	5	Capacitor	Not assembled	
C16	15 pF	1	Capacitor 50 V, C0G, NPO, 0402	GRM1555C1H150JZ01	Murata
C18	1 µF	1	Capacitor ±10%, X5R, 0603	Generic part	
C19	22 pF	1	Capacitor ±5%, 50 V, C0G, NPO, 0603	GRM155R71C223KA01	Murata
C20	33 pF	1	Capacitor ±5%, 50 V, C0G, NPO, 0603	Generic part	
C21	2.2 µF	1	Capacitor ±10%, X5R, 0603	Generic part	
C27	4.7 µF	1	Capacitor ±10%, X5R, 0603	Generic part	
D1 and D2	LED	2	SMD LED 0603	D1 = Red; D2 = Green	
D3 and D4	Diodes	2	Diodes	Generic parts 1N4148 or equivalent	
D5	TSHF5210	1	Typical RED GaAs LED	TSHF5210 or equivalent	Vishay
E1	AN0835	1	Generic antenna	3030A5645-01 Mica 2.4 GHz	Antennova
FLT1	WE748351124	1	Filter	WE748351124	Wurth
IC1	STM32W	1	STM32W	STM32W108CBU	ST
IC2	FT232R	1	FT232R	FT232RL SSOP-28	FTDI
J1	MCX	1	Connector	Not assembled	
J2	USB_MiniB	1	Connector	Generic part	
JP4	Header 2	1	Header, 2-Pin	Header, 2-Pin, single row Male	
L1	2.7 nH	1	Inductor 300 mA 0402	LQP15MN2N7B02	Murata

Table 12. List of components (continued)

Marking	Comment	Qty.	Description	Reference	Manu-facturer
L2	5.1 nH	1	Inductor 300 mA 0402	LQG15HS5N1S02D	Murata
P1	Debug/ Trace	1	Header, 5-Pin, Dual row	FTSH-105-01-F-DV-K	Samtec
P2	Header 14x2	1	Header, 14-Pin, Dual row, straight	Header, 14-Pin, Dual row Male	
P3	Header 3x2	1	Header, 3-Pin, Dual row	Header, 3-Pin, Dual row Male	
R3, R4 and R13	1 kΩ	3	Resistor	Generic part	
R1 and R12	10 Ω	2	Resistor	Generic part	
R2	nc	1	Not assembled	Generic part	
R5 and R9	10 kΩ	2	Resistor	Generic part	
R6	470	1	Resistor	Generic part	
R7	180 kΩ (1%)	1	Resistor	Generic part	
R8	1 Ω	1	Resistor	Generic part	
R10 and R11	0 Ω	2	Resistor	Generic part	
Rst and S1	SW-PB	2	SMD switch button	Generic part	
T1	WE748-422-245	1	Balun 50/200 Würth	WE748-422-245	Wurth
U1	LIS302DL	1	Digital MEMS Accelerometer	LIS302DL	ST
U2	STLM20W 87F	1	Precision Analog Temperature Sensor	STLM20W87F	ST
U3	LK112	1	Voltage regulator	LK112SM33TR	ST
X1	24MHz	1	Crystal ±10 PPM Tol., ±25 PPM Stab., 18 pF, -40° to +85° C	NX2520SA 24MHz EXS00A-CS01145	NDK
X2	32.768kHz	1	Quartz	NX3215SA 32.768KHz EXS00A-MU00007	NDK
Q1	BC846W or equivalent	1	NPN General Purpose Amplifier	Generic part	

Revision history

Table 13. Document revision history

Date	Revision	Changes
18-Nov-2009	1	Initial release.

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